SOME ANTENNA OBSERVATIONS
Part 1

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For almost a year, the author has been collecting data to determine the performance of various antennas for use with the VLF-3 INSPIRE Receiver. The goal is to determine which antenna is “best” for my particular location and noise environment, (*these results may not generalize to other locations and environments*). This paper is divided into two parts. In Part 1, results relating to about half the antennas tested will be presented. The rest will be presented in Part 2.

Antennas Considered. The antennas considered for use generally have to meet three criteria.

First, the materials to construct the antennas have to be readily available and the design must not require professional machine shop work.

The second restriction is that the antenna materials have to be inexpensive. I set a limit of $50 per antenna, although most of the prototypes were quiet a bit less than this.

The third restriction is that a single person must be able to assemble and erect the antenna. Also, the antenna has to fit in the bed of my truck. This means that each piece of the antenna can be no longer than 6-feet.

Given the above constraints, I ended up evaluating the following antennas. A detailed description, including sketches and photographs, is in the appendix.

a. Vertical monopole (whip), 6-Feet in length, mounted on a wood support that elevates the base of the antenna about 3-Feet above ground level. The antenna has two feeder connection points, one for an open wire line and one for a coax cable.

b. Sloping Long Wire Antenna, 120-Feet in length. A 20-foot telescoping mast supports the taller end. The lower end is 3-Feet above ground. The antenna is made of 14-guage stranded, insulated, electrical cord.

c. Vertical Monopole, 4-Feet in length and mounted atop a 20-foot PVC pipe mast. The antenna is fed with RG-59 Coax cable. I used a 50-Foot length of coax so that the antenna can be located well away from the monitoring position.

d. 500-Foot Long Wire Antenna. Made of insulated wire and supported above ground by throwing on top of low bushes.

e. 1000-Foot Long Wire Antenna, same as above except longer.

f. Ferrite Loop Antenna.
g. Box loop antenna.
h. "Tree" antenna.
i. "Wet Sand" antenna. The tree and wet sand antennas were the subjects of extensive discussion on the VLF Group (VLF_Group@yahoogroups.com).

Evaluation Technique. The 6-foot vertical whip was selected as the reference antenna. The general technique was to first connect the reference antenna to the VLF-3 receiver and record from 15 to 30 Minutes of natural radio signals. The VLF-3 was adjusted for maximum gain and the recorder gain adjusted so that its level meter was in the green zone and slightly below the red line (recorder saturation). Next, the reference antenna was replaced with the antenna to be evaluated and an additional 15 to 30 minutes of natural radio recorded. All recorder and VLF-3 settings were held constant.

Usually a second "run" with the same antennas but with the VLF-3 antenna attenuator in the "in" position was made.

Most of the experiments were conducted at night, between the hours of 2000 and 0100 local time. However, some of the experiments were repeated to obtain data during the daytime. The daytime periods varied but usually occurred between 0800-1000 and 1500-1700 local time.

Spectrum analysis programs (SpectraPlus and Gram) were used to analyze the data on the tapes.

RESULTS

The following charts show the results. Figure 1 is the performance of the reference antenna with the VLF-3 antenna attenuator “out” then “in”. This figure clearly shows the presence of Loran when the antenna attenuator is out. The Loran signal appears as peaks in the spectrum at multiples of 1 kHz. The Loran signal is completely eliminated by placing the attenuator in the “in” position. However, the penalty one pays for eliminating Loran is a 6-10 dB decrease in signal level at all frequencies.

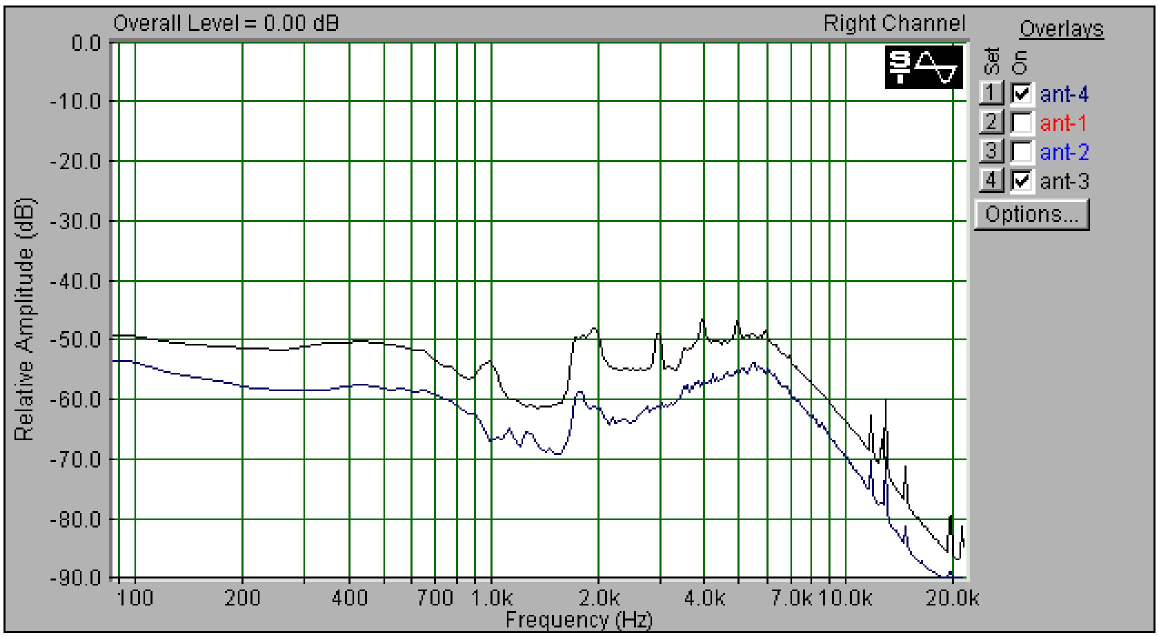

Figure 1 Reference Antenna. Top trace is with VLF-3 Attenuator “out”. Bottom trace is with attenuator “in”.

Figure 2 shows the results obtained using the 120 Foot long wire antenna. These results are interesting and were unexpected. The figure shows that the long wire provides about 10 dB more signal across the band than did the reference antenna. Loran is present when the VLF-3 attenuator is “out” and not present when the attenuator is “in”. However, note in figure 2 that the level differences with the attenuator “in” versus “out” are not significant in the bands of interest for natural radio, 1 to 10 kHz. This result was not expected!

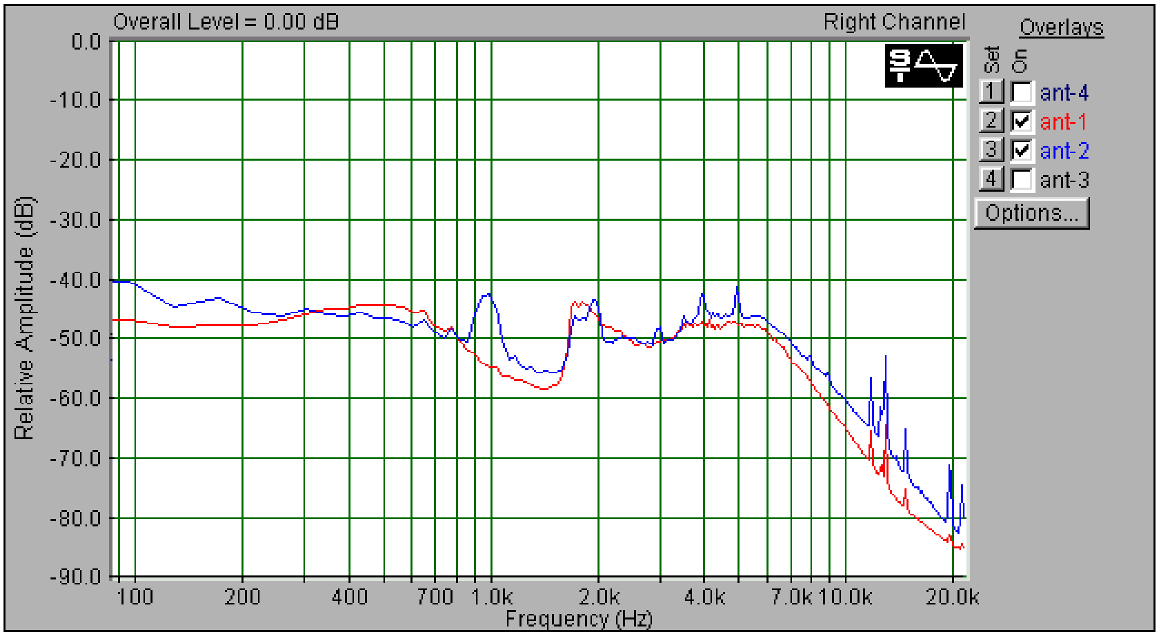

Figure 2   Comparison of 120 Foot Long wire antenna with VLF-3 attenuator "out" (top trace) and "in" (bottom trace)

Figures 3 and 4 show plots of the reference antenna and the 120 Foot Long Wire on the same chart. The difference between the signal pick up by the two antennas is very clear in figure-3 but less pronounced in Figure 4. Figure 4 clearly shows Loran pick up by both antennas and the long wire provides several dB more Loran signal than does the reference antenna.

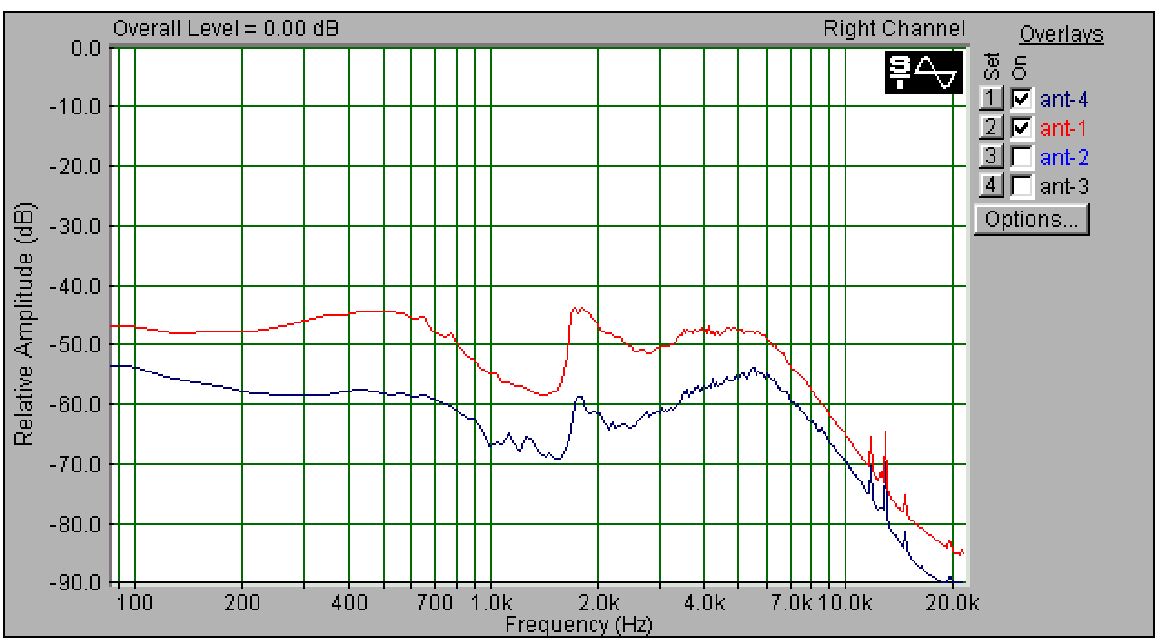

Figure 3   Comparison of 120-foot long wire (top trace) with 6-Foot Vertical reference (bottom Trace) with VLF-3 attenuator "in".

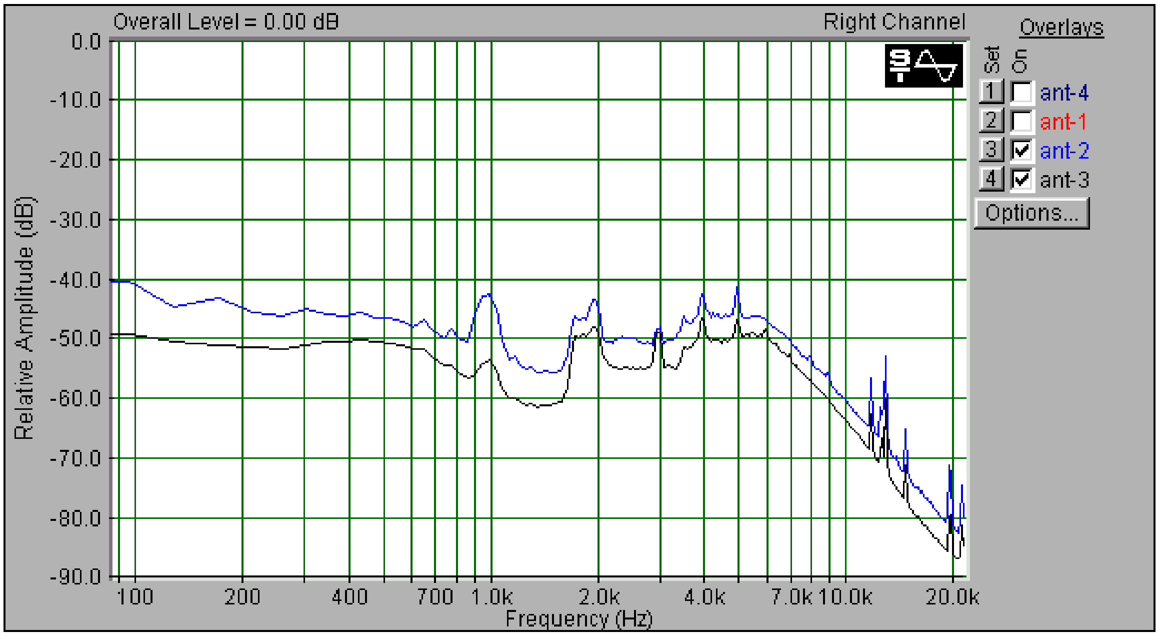

Figure 4 120-Foot long wire (Top trace) versus
6-Foot Whip (bottom Trace) with VLF-3 attenuator "out".

The 120 foot long wire antenna also picked up more 60~ power line interference than the 6 foot whip. Figures 5 and 6 show this effect. Figure 5 is for the long wire and clearly shown stronger 60~ harmonic interference than the 6 foot whip in Figure 6. The interference appears as horizontal lines in the charts.

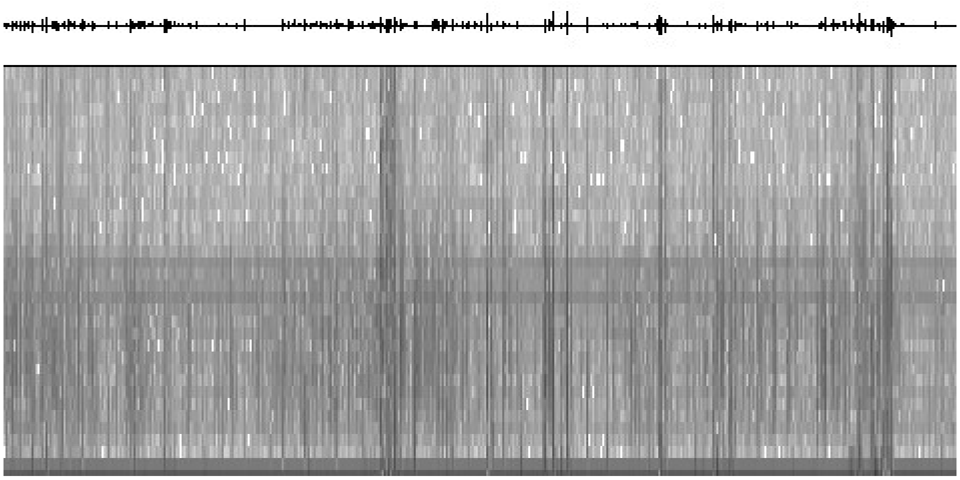

Figure 5 120- Foot Long wire. GRAM spectra of the 0 to 1 kHz portion of spectrum.

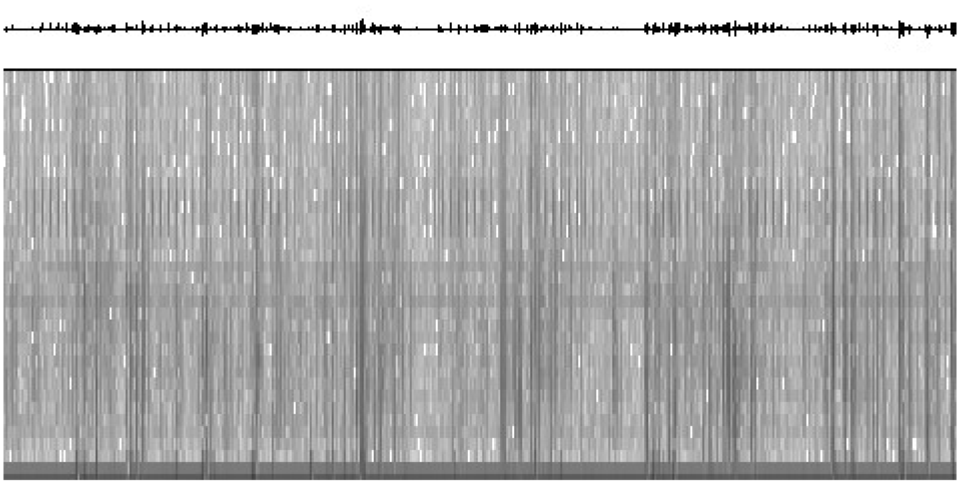

Figure 6 Reference antenna. Gram plot of 0 to 1 kHz portion of spectra.

The next antenna considered was the elevated 4-foot whip using a coax feed line. Figure 7 shows a comparison of the elevated whip with the reference antenna. In this experiment, the VLF-3 antenna attenuator was “out”. Two things stand out in this chart. First, the natural radio signal levels are about the same for both antennas. Second, the elevated whip using a coax feed effectively removed the Loran signal, which is very clear in the trace for the reference antenna. The shunt capacitance of the coax is probably sufficient to attenuate the Loran signal without significantly affecting the natural radio signals.

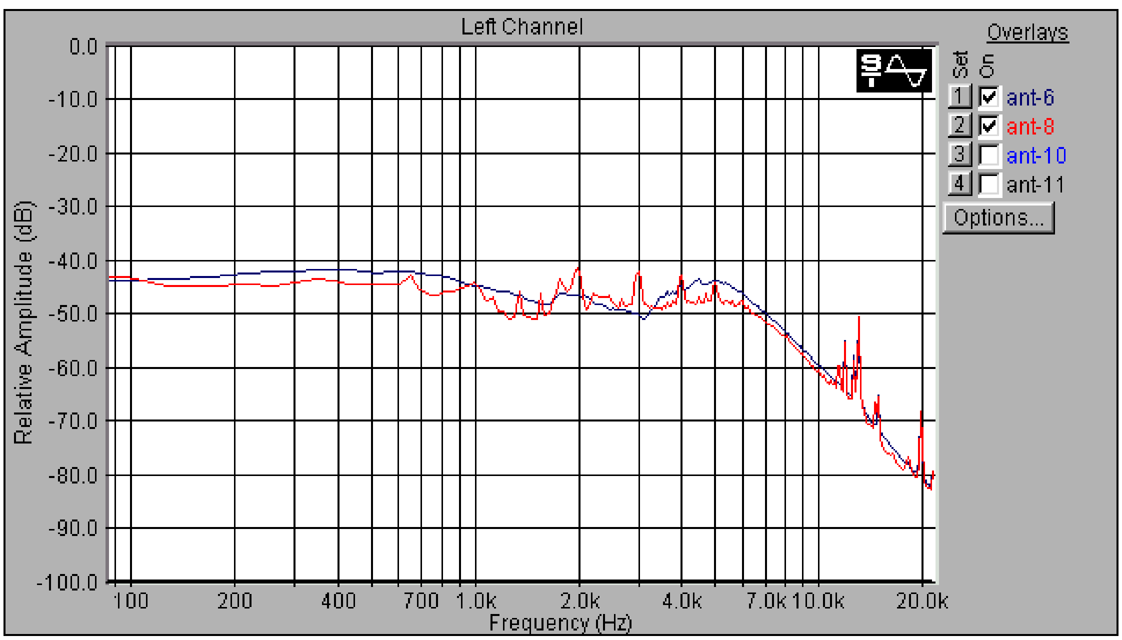

Figure 7 Comparison of reference antenna (bottom trace) with elevated whip fed with coax (upper trace). VLF-3 attenuator “off”.

Figure 8 shows the effect of placing the VLF-3 attenuator "in". Note that the reference antenna curve does not show any trace of Loran. The elevated antenna trace remains free of Loran. However, note the differences in signal levels in the 10-20 kHz region. It seems that the VLF-3 attenuator in combination with the shunt capacitance of the coax is forming a low pass filter that has its cutoff point at about 6 kHz.

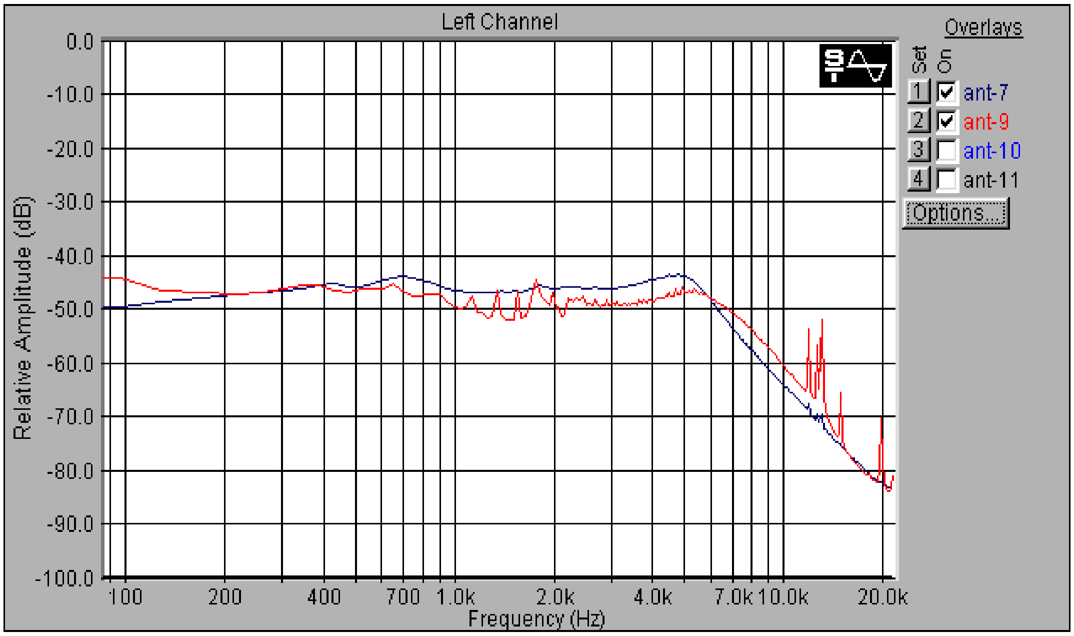

Figure 8 Reference Antenna (lower trace) and elevated whip (upper trace) with the VLF-3 attenuator "on".

Day versus night. Figure 9 is one example of the differences between daytime signal levels and nighttime levels. All the other experiments reveal the same trends so for the sake of brevity; only this example will be discussed. The data shows that nighttime natural radio levels (tweeks, sferics, whistlers, etc) are generally stronger than daytime levels but the differences are not constant. During some experiments the difference was only a dB or so and in others like the one presented, the levels differ by 10-12 dB. The manmade signals (Loran, plus communications and navigation signals between 10 and 20 kHz) are usually much stronger in the daytime than at night. Also, the daytime spectra usually shows stronger 60~ power line interference, normally odd harmonics. Note the spike in the daytime spectra at 660 HZ (11th harmonic).

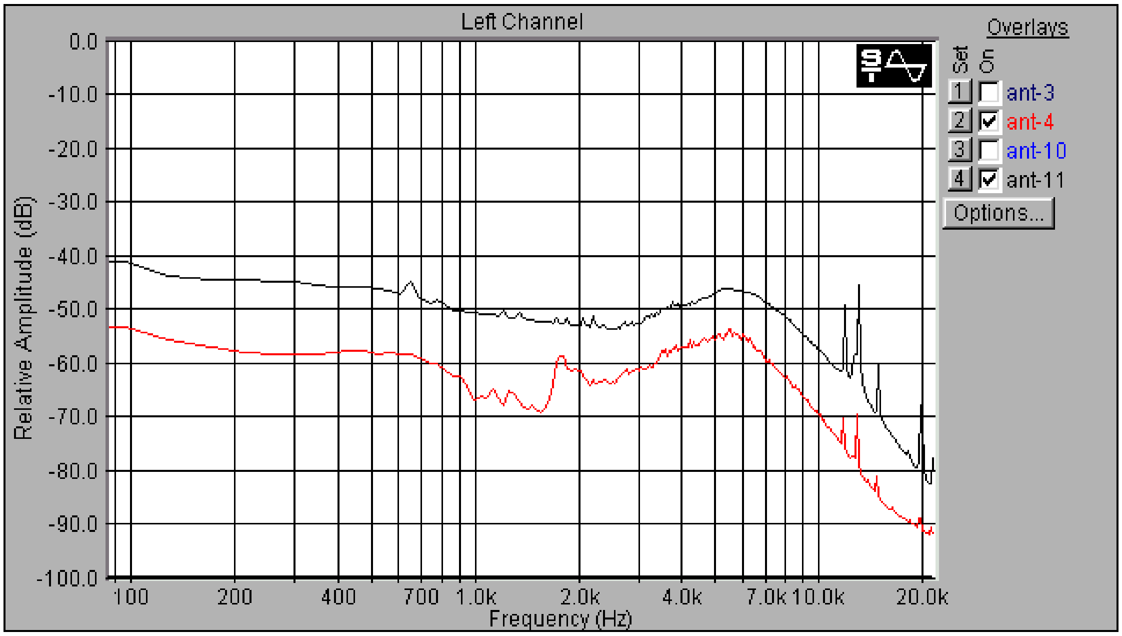

Figure 9 Day (top trace) versus Night (Bottom trace) signal levels
using the reference antenna with VLF-3 attenuator "on".

The last experiment to be discussed is the 500-foot long wire antenna. The antenna was oriented generally in an East-West direction and supported by placing it in the tops of dormant creosote and mesquite bushes. The height above ground varied between 1 foot and 3 feet and care was taken to prevent the insulated wire from contacting the ground. Previous experimentation showed that if the wire is allowed to contact the Earth for any appreciable distance, then the levels of power line interference increase greatly. Figure 10 shows the results. This experiment was performed in the daytime and the VLF-3 attenuator is "in". Two things are immediately evident. First, the long wire provides more signal pick-up at frequencies below about 2 kHz than does the reference antenna. From 2-10 kHz, the antennas are about the same and above 10 kHz, the reference antenna is better. Second, the 500-foot long wire picks up substantially more 60~ interference than does the reference antenna. Note the strong 60~ odd harmonics at 300, 660, 780, 1500 and 2100 Hz.

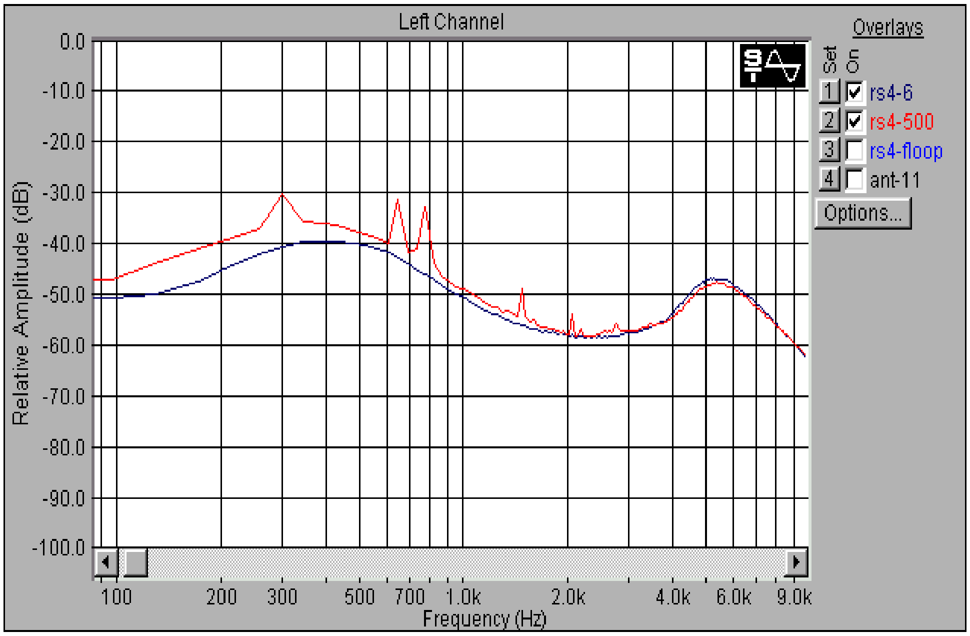

Figure 10 Comparison of a 500-foot long wire antenna (top trace) with the reference antenna (bottom trace).

CONCLUSIONS

From the information presented, the following conclusions can be drawn:

a. The antenna attenuator on the VLF-3 receiver will effectively eliminate Loran interference when using any of the experimental antennas.

b. Use of the VLF-3 attenuator is not without penalty. Its use can result in up to a 10-dB loss in receiver sensitivity.

c. The long wire antennas provide additional signal pick up but at the expense of increased 60~ interference.

d. An elevated whip antenna connected to the VLF-3 receiver (attenuator “out”) with a coax cable feed provides about the same performance as the ground mounted 6-foot whip reference antenna with the VLF-3 attenuator “in”. The appeal of the coax cable feed is that it can be used to attenuate Loran without using the VLF-3 antenna attenuator.

e. So far, the author has not found a compelling performance reason to replace the simple ground mounted 6-foot whip reference antenna with a more complex antenna.

f. The use of coax cable to eliminate Loran interference is attractive and can easily be applied to the reference antenna. This will be further investigated in the future.